COEUR D'ALENE BASIN
REPOSITORY SITING ANALYSIS

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Abstract

Locating potential long-term, permanent repository sites for heavy metal-contaminated soil and sediment within the Coeur d'Alene River basin using the latest geographic information system (GIS) methodology resulted in useful graphic displays of possible sites. Software and data limitations must be fully understood to assure that search criteria provide site depictions that are neither too liberal nor overly restrictive in number or size of potential sites.

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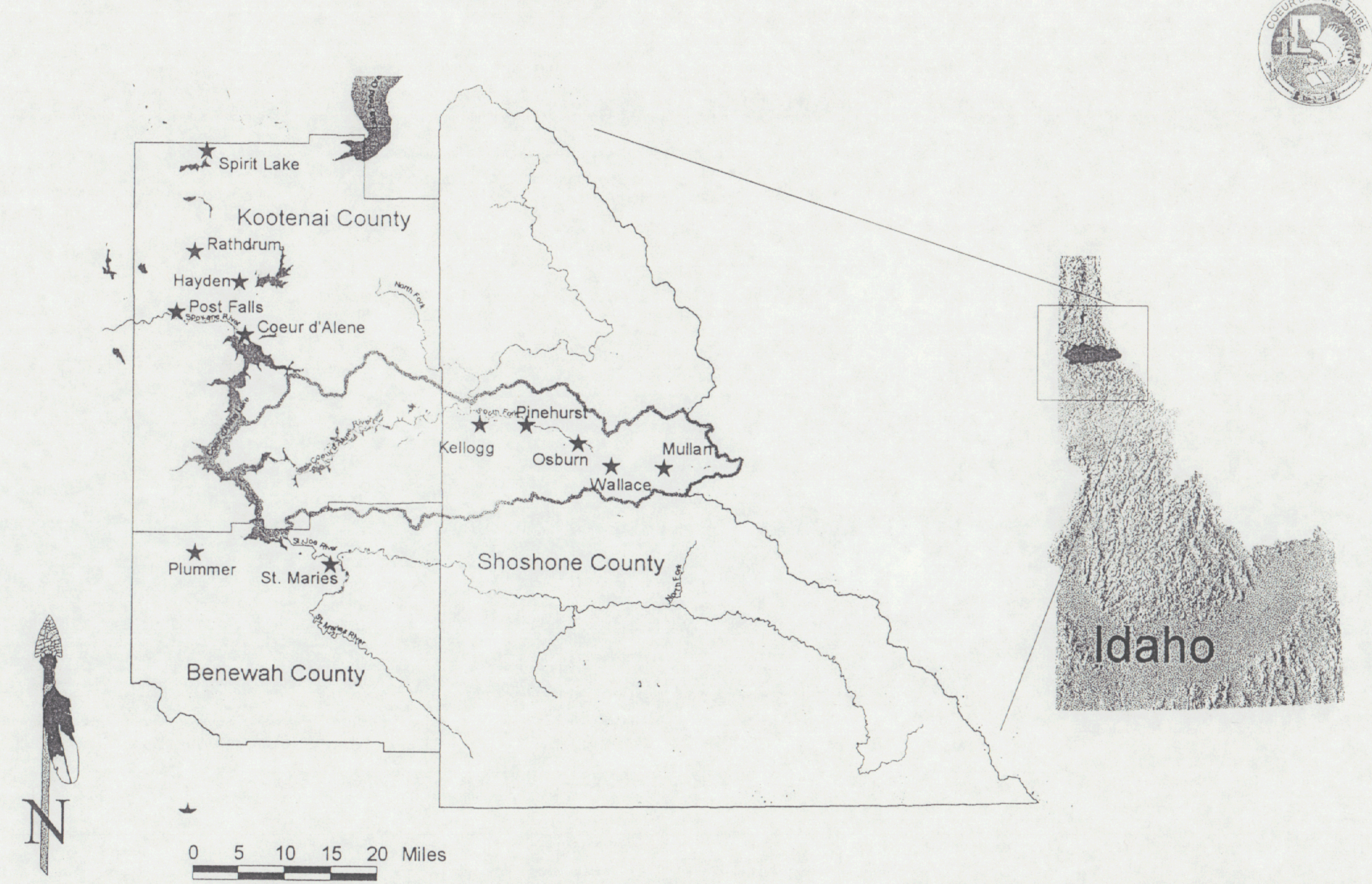
Introduction

A century of hard-rock mining, milling and ore processing in Idaho's Silver Valley, located within the Coeur d'Alene River Basin (Figure 1) has resulted in tailings, waste materials and trace metals-contaminated sediment deposits in and along the South Fork Coeur d'Alene River (SFCDAR) and most of its tributaries. By some estimates approximately 72 million tons of these trace metals-contaminated tailings were released into the SFCDAR (Horning et al., 1988). Much of this waste, mixed with stream alluvium, washed downstream into the lower Coeur d'Alene River, lateral lakes wetlands, Lake Coeur d'Alene and the Spokane River (Harrington et al., 1988; Horowitz and Elrick, 1995; Keely et al., 1976).

In 1983 the U. S. Environmental Protection Agency (EPA) designated 21 square miles surrounding the Bunker Hill Industrial Complex in Shoshone County, Idaho as a Superfund Site (BHSS). The EPA has recognized thirteen toxic substances in its designation, including lead, cadmium, antimony, arsenic, asbestos, beryllium, cobalt, copper, mercury, selenium, silver, zinc and polycholorinated biphenyls (PCBs). Cleanup within the BHSS has been ongoing since the early 1990's using various techniques. The most prominent method of metals remediation has been removal to the Central Impoundment Area (CIA) site. This site is not an approved repository and it is uncertain if, once capped, metals loading via surface and groundwater pathways will be eliminated.

Figure 1. Area of study for Coeur d'Alene River repository siting study



Map Produced by Coeur d'Alene Tribe GIS 7/10/98

Large quantities of "within the box" tailings and metals-contaminated soil have been and are being placed in the CIA, but current EPA plans will permanently close this repository by September, 1999. Additionally, use of this site has been largely restricted to wastes originating from within the 21 square mile site. Therefore the availability and suitability of this site for waste materials upstream or downstream of the "box" is rather limited.

In addition to the BHSS, it is widely known that large quantities of tailings and metals-contaminated soil/sediment are located in the headwaters of the SFCDAR (above BHSS) as well as downstream to Cataldo and beyond into Coeur d' Alene Lake. Cleanup of these upstream deposits has been underway by various groups since 1993. The EPA is currently developing an RI/FS for the remainder of the contaminated basin upstream and downstream of the BHSS-areas not included in the original RI/FS or Record of Decision. Completion of this investigation and feasibility study is expected sometime in 2000. The Coeur d'Alene Tribe, the U. S. Department of Agriculture and the U.S. Department of Interior are also conducting a Natural Resource Damage Assessment (NRDA) to determine restoration opportunities in the basin. Both the NRDA and the RI/FS will likely suggest extensive removal projects in both the upper and lower basin areas.

Although numerous in-situ stabilization/revegetation pilot-project cleanup methods have been proposed or tried, the most widespread and proven disposal method to date is removal to a temporary waste disposal site or a safe, permanent repository area. A small waste disposal site was established over an existing, abandoned mine tailings pond (Day Mines) in the Nine Mile

Creek watershed to store contaminated removal material from this drainage. Another much larger disposal site was created in 1995 in lower Canyon Creek (Woodland Park Site), specifically to receive tailings and contaminated soil dug out from lower Canyon Creek and the adjacent floodplain.

Location, safety and feasibility of these two repositories were studied briefly as part of the various project proposals, but they were not developed as part of any basin wide repository analysis. Both the U.S. Forest Service and Bureau of Land Management (BLM) have planned waste disposal developments as part of their respective removal efforts in Moon Creek and Upper Pine Creek. The BLM facility in Upper Pine Creek, however, is a temporary storage area.

Objectives

Since it was the collective thought of agency and industry personnel working on the Coeur d'Alene basin cleanup that additional repositories were needed for future remedial work, the following objectives were developed: (1) Develop repository location criteria; (2) Identify potential mine waste repository sites within the South Fork Coeur d'Alene River and Lower Coeur d'Alene River systems and develop repository location maps for resource managers.

In 1994 an interagency/industry effort under the leadership of the Coeur d'Alene Basin Restoration Project developed repository siting and planning guidelines for use throughout the basin.

These voluntary guidelines, finalized and accepted by the workgroup in 1995, were used as a starting point for this current repository siting analysis.

The need for a screening and planning analysis to identify potential repository sites using objective screening criteria surfaced in 1997. A workgroup of industry, agency and Tribal technical staff developed the following results using existing basin GIS database and analysis information (see Appendix 1 for participants). Various geologic, hydrologic, biologic and social factors were considered in development of screening criteria. Following is a summary report of this process and the results of the analysis.

METHODS

The GIS analysis for this project was divided into two phases. Phase I involved setting up the initial criteria for the project and convening a workgroup decision making meeting. Phase II involved refinement of the criteria and rerunning the analysis. The analysis was divided into two steps: the Arc/Info analysis and the ArcView/GeoChoice group analysis. Three different types of GIS software were used in the repository siting project: ESRI's **Arc/Info** and **ArcView,** and GeoChoice's **Choice Explorer**. Arc/Info was used to create the GIS layers used for the project. ArcView and Choice Explorer allowed the workgroup participants to view the data sets and evaluate each of the proposed sites by ranking based on their own personal importance of each of the criteria.

PHASE I

Arc/Info Analysis

Initially the project coordinator contacted all members of the Coeur d'Alene Basin Restoration Project (CBRP) repository siting working group to develop a list of general GIS layers that might be suggested as tentative siting criteria (Table 1). The list was then evaluated to determine if suitable GIS layers existed or could be created for each of the criteria. A display of the GIS layers used for the project and the sources for each can be found in Table 2.

Using these original GIS layers (Table 2), Arc/Info was used to produce new GIS layers that reflected the project criteria. Example: the BUFFER command was used to buffer the streams layer to produce streamside zones that would be exempt from consideration as potential repository sites (Figure 2). The buffer distances were determined by interviews of the CBRP repository siting group members, plus additional input from individuals with technical expertise in technical specialties such as biology and hydrology. The buffer distances for each of the applicable GIS layers are displayed in Table 3.

Once all the GIS layers that needed buffer zones were completed and other coverages were acquired or digitized, all of these layers were converted into Arc/Info grids using the POLYGRID command. The grids were then combined into one large grid having the attributes of all the GIS layers using the Arc/Info Grid command COMBINE. This new combined grid could then be queried for the desired criteria. An Arc/Info macro program was developed to assist the GIS Analyst to interactively select the criteria and evaluate the results on the computer screen. When all the criteria were selected, the queried cells were used to generate a new GIS grid. The

Table 1. List of suggested criteria-- Repository Siting Analysis: Coeur d'Alene River Basin

Criteria Name	*How Criteria Will Be Used*
Streams	Exclude buffered area around stream
Lakes	Exclude buffered area around lake
Rivers	Exclude buffered area around rivers
Schools	Exclude buffered area around schools
Floodplains	Exclude area in floodplain
Slopes	Exclude area of certain high slope angles
Distance from water	Evaluate site on distance from water
Distance from flood-plain	Evaluate site on distance from floodplain
Population density	Evaluate site on area's population density
Buildings	Evaluate site on number of building on site
Distance from floodplain	Evaluate site on distance from floodplain using road network
Rare plants and animals	Exclude buffered area around some plants and animals
Cultural locations	Exclude buffered area around known cultural sites
Elevation of sites	Evaluate sites using elevation above floodplain
Geology and faults	Evaluate sites based on geologic conditions

Table 2. List of GIS layers--Repository Siting Analysis:Coeur d'Alene River Basin

Criteria Name	***How layer was created/sources***
Streams	BLM, IDL, USFS, Tribe, USGS: 1:24,000 stream GIS data
Lakes	BLM, IDL, USFS, Tribe, USGS: 1:24,000 lake GIS data
Rivers	BLM, IDL, USFS, Tribe, USGS: 1:24,000 river GIS data
Schools	Maps provided by each school district
Floodplains	FEMA floodplain maps/USFS land types
Slopes	Derived from USGS 30m DEM
Distance from water	Derived by proximity analysis in Arc/Info using above hydrology layers and repository site layer
Population density	Bureau of Census Tiger Data 1:100,00
Buildings	Building identified on USGS 1:24,000
Distance from floodplain	Distance derived by proximity analysis in Arc/Info using above hydrology layers and repository sites layer
Rare plants and animals	Derived from IDFG CDC data set
Cultural locations	Tribal cultural sites layer
Elevation of sites	Evaluate sites using USGS 30m DEM elevations and floodplain
Geology and faults	Based on 1:24,000 Hobb=s Geologic maps of the Silver Valley
Federal ownership	Derived from BLM ownership layer

Figure 2. Buffered Streams Example

Table 3. Phase I Buffer Distances--Repository Siting Analysis: Coeur d'Alene River Basin

Criteria Name	*Buffer Distances (meters)*
Streams	75/50
Lakes	200
Cultural Locations	75
Rivers	200
Schools	500
Bald Eagle	1600
Barred Owl	879
Black Tern	1629
Black-backed Woodpecker	586
Boreal Owl	218
Coeur d'Alene Salamander	200
Fisher	1926
Flammulated Owl	218
Long-eared Myotis	142
Lynx	3177
North American Wolverine	11154
Northern Alligator Lizard	36
Northern Pygmy Owl	1630
Pygmy Nuthatch	564
Western Grebe	923
Upland Sandpiper	723
Upland CDC Plants*	100
Wetland CDC Plants*	300

* Table of CDC (Conservation Data Center) plants can be found in Appendix 2

potential repository sites grid represented the first round of criteria (Figure 3) which is indicative of the entire Coeur d'Alene River Basin.

This grid was then converted into a polygon layer using the Arc/Info command GRIDPOLY. Once the layer had been converted, it was attributed with additional information using the IDENTITY command. Example: the potential repository site layer was combined with Bureau of Census data so the output polygons would carry population density information attached to them. Amendments were done to add the following items onto the polygons: (1) number of buildings, (2) federal ownership, (3) population density, (4) occurrence of the polygons in wolverine range, eagle range, and fisher range.

The final attribute added to the layer was the location of an image of the site. Photographs were taken of many sites; then using the Hotlink feature found in ArcView, the users could select a polygon and display a photograph of the area selected (Figures 4, 5). Once the polygons had been attributed, they were ready for the ArcView/GeoChoice group analysis.

ArcView/GeoChoice Group Analysis

For this step of the analysis, two pieces of software were used: ESRI's ArcView and an ArcView extension called Choice Explorer created by GeoChoice. This software was used as a group decision making tool. It allowed the workgroup users to query the GIS data, then select and rank criteria based on their own personal opinions. Because this software was limited to 70 sites, the potential repository sites where further restricted by only evaluating sites over 15 acres in size (See Figure 6).

Table 4. Buffer distances modification for South Fork of Coeur d'Alene River

Criteria Name	*Phase II Buffer Distances (Meters)*	*Phase I Buffer Distances (Meters)*
Streams (perennial/intermittent)	15/15	75/50
Lakes	46	200
Rivers	46	200

Arc/Info Analysis

As in Phase I of the analysis, Arc/Info was used to recompile the dataset using the new buffer distances for the South Fork of the Coeur d'Alene River (upper basin). Compilation methodology was the same as in Phase I (except for slight modifications that were made in the AML that was designed for the analyst to query the dataset. These modifications were made due to evolutions in the core Arc/Info software when the software went from Version 7.1 to Version 7.2). After all the Arc/Info analysis was complete, a new grid was produced representing the sites that met the new criteria for the ArcInfo analysis for the South Fork of the Coeur d'Alene River (Figure 7).

ArcView Analysis

In this step, ArcView was used to further restrict proposed sites for the South Fork of the Coeur d'Alene River. This was done by eliminating all sites that had acreage less than one acre. A map of the selected sites is displayed in Figure 8.

Discussion

Removal of metals-contaminated materials to a repository site has been used as a, long-term remedial solution to date. However, availability of repository sites in steep, wet, narrow-canyon, mountainous terrain that predominates in the upper basin could be a critical and costly limitation to future removal efforts. Lower basin (below Cataldo) terrain is more open and rolling, but the extensive valley bottoms are subject to seasonal flooding or stream erosion. More moderately sloped (lower and midslope) terrain is largely in private ownership, homesites or active farm operations. Preliminary quantity estimates of soil, sediment and tailings that may require placement in some type of repository are very large, exceeding 30 million cubic yards under a full restoration alternative (Ridolfi Engineers, 1993).

Haul distance (from removal sites to future repositories) is a critical element in the economic feasibility of any removal project. It may be too costly to haul large quantities of waste 10-30 miles to a few, widely scattered large repositories. The ideal scenario may include numerous potential repository sites dispersed throughout the upper and lower basin areas, in relatively close proximity to future removal projects. Use of existing tailings ponds for long-term repository siting is questionable due to leaching of metals-contaminated surface water into ground water sources.

In Phase I of this project the initial repository siting criteria was created and evaluated by the workgroup. This was accomplished by developing the GIS database and integrating the group decision making software package discussed in the methods section. It is important to note that due to limitations imposed by the Choice Explorer Software package, locations depicted on Figure 3 were further refined so that only sites greater than 15 acres in size were selected (software limitations permitted evaluating only 70 sites). This limited the evaluation of potential sites in the entire basin, as reflected in figure 6, to only fifty-three locations. Of the fifty-three locations identified in the Phase I group analysis session, (given the initial siting criteria in Table 2, and Phase I buffer distances associated with specific criteria in Tables 2 and 3) the majority are located in the lower Coeur d'Alene Basin (below the confluence of the

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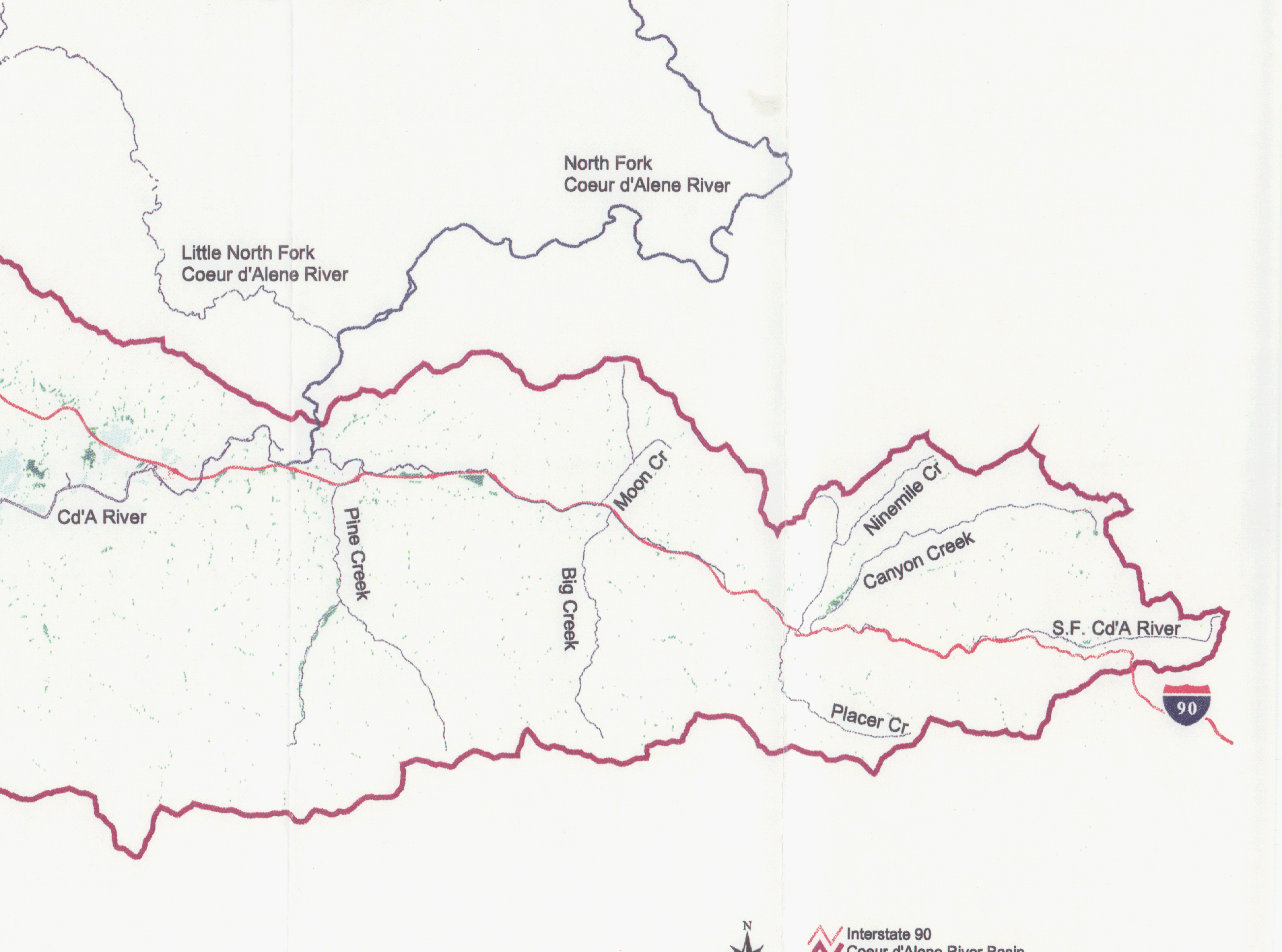
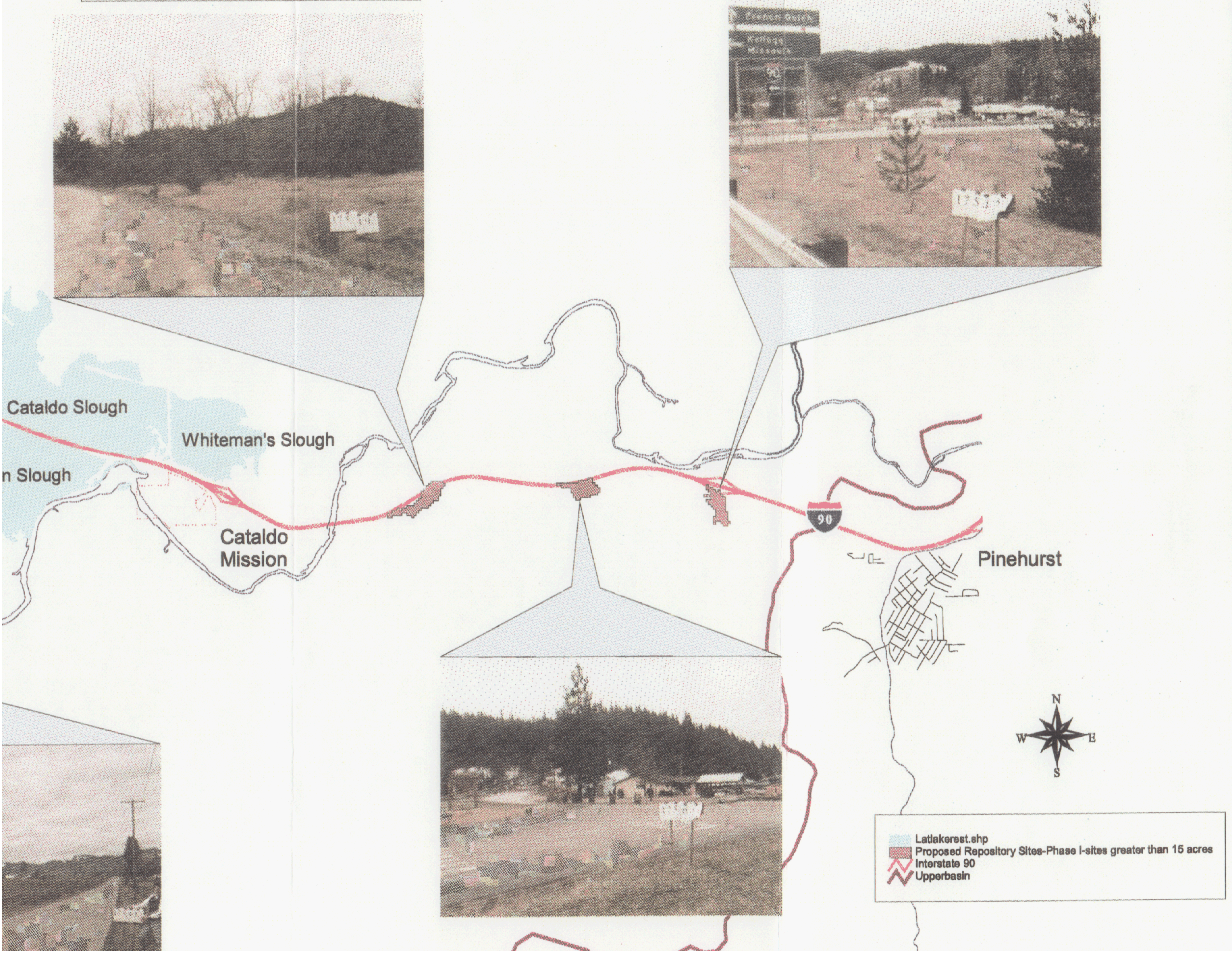
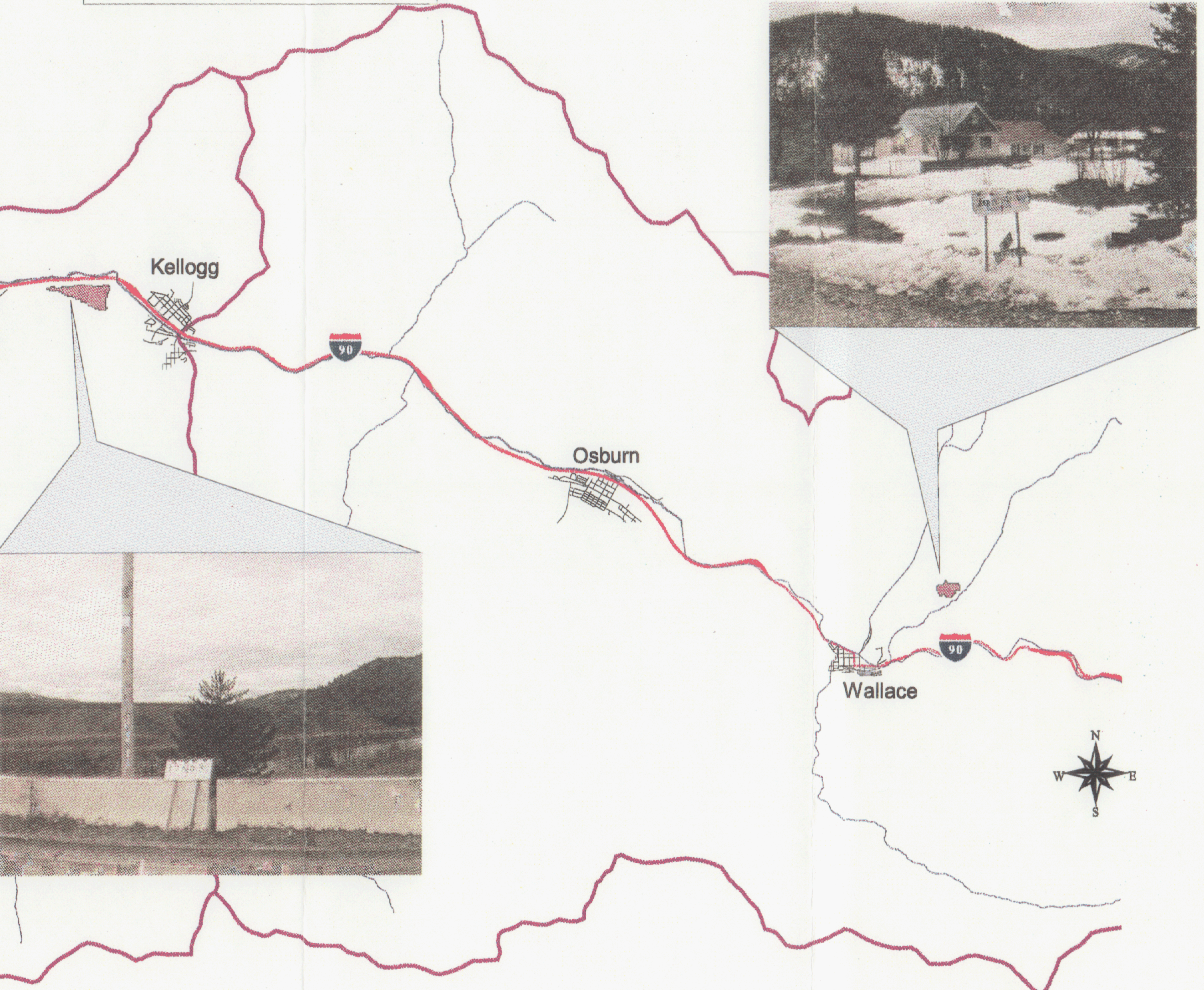

North Fork
Coeur d'Alene River
Little North Fork
Coeur d'Alene River
Cd'A River
Pine Creek
Big Creek
Moon Cr
Ninemile Cr
Canyon Creek
S.F. Cd'A River
Placer Cr.
90
N
Interstate 90

Lower Basin Typical Sites 15 acre +



Lower Basin Typical Sites 15 acre +

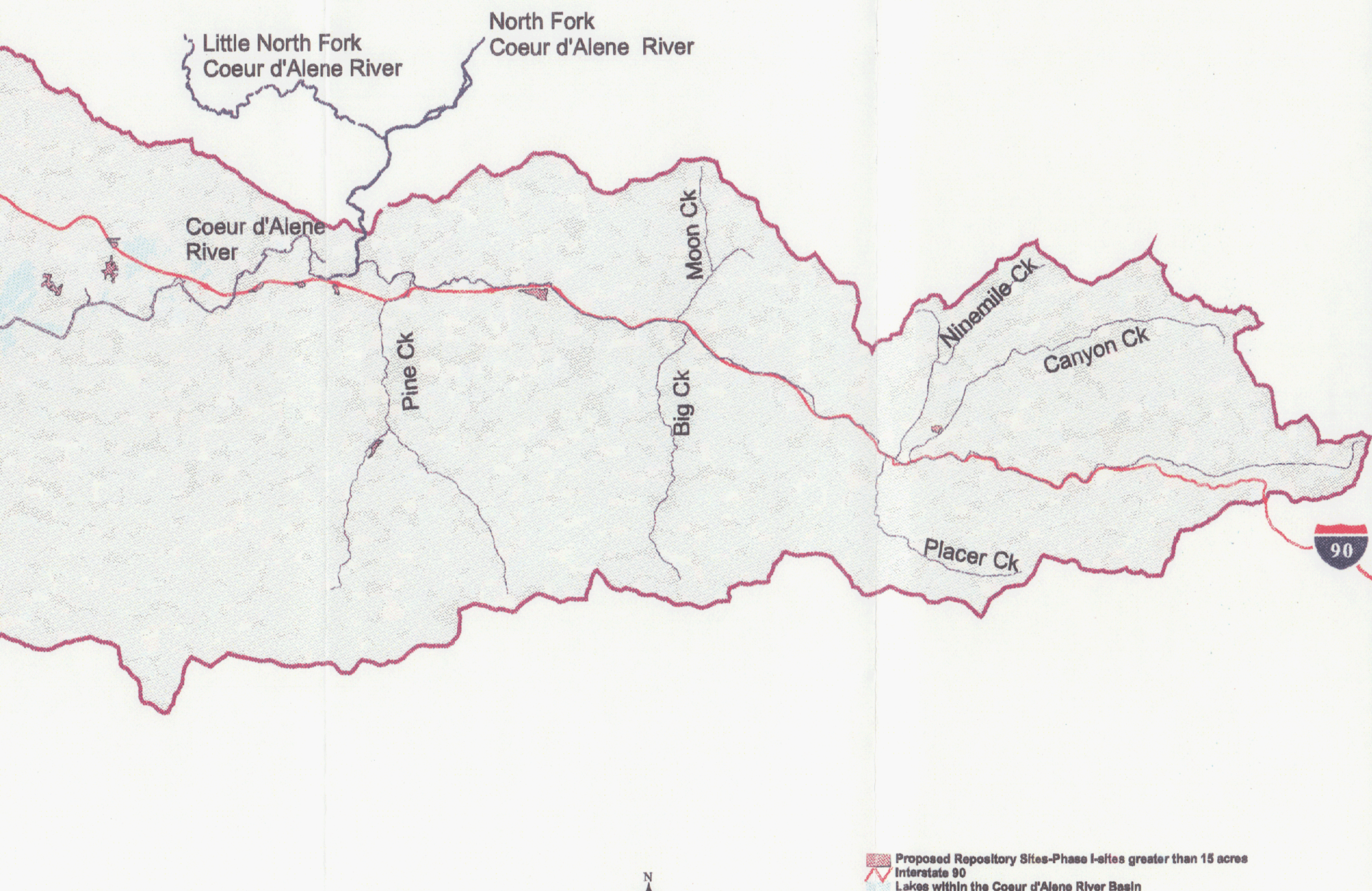


The group then used the Choice Explorer software to vote on which of the 10 cri they wished to use for the exercise. The ten criteria included: elevation, elevation above floodplain, number of buildings, population density, wolverine range, eagle range, fisher range, site size, and distance from water. After criteria selection, each was ranked by eac the participants. Once the individuals had ranked the criteria and after exploring their loc on the GIS and viewing photographs of the sites, it was determined that Geochoice was a potentially useful tool in the multiple criteria decision making selection process. However this analysis no additional use of Geochoice was made.

PHASE II

After evaluation of the repository sites (as displayed in figure 6), group feedback revealed that the first round of criteria needed modifications for the upper basin. Phase I not identify adequate upper basin potential sites, and some modifications were needed to broaden the site search; therefore, Phase II only addressed the upper basin above the Nor Fork and South Fork Coeur d'Alene River confluence. Changes included shrinking severa the buffer distances for the hydrologic coverage of the South Fork Coeur d'Alene River (Table 4). Phase II did not include a group collaborative decision making process using tl GeoChoice Software. However it did involve using ArcView to narrow selection of sites

Repository Siting Analysis - Phase I
August 1998



Initial ArcInfo Analysis
August 1998

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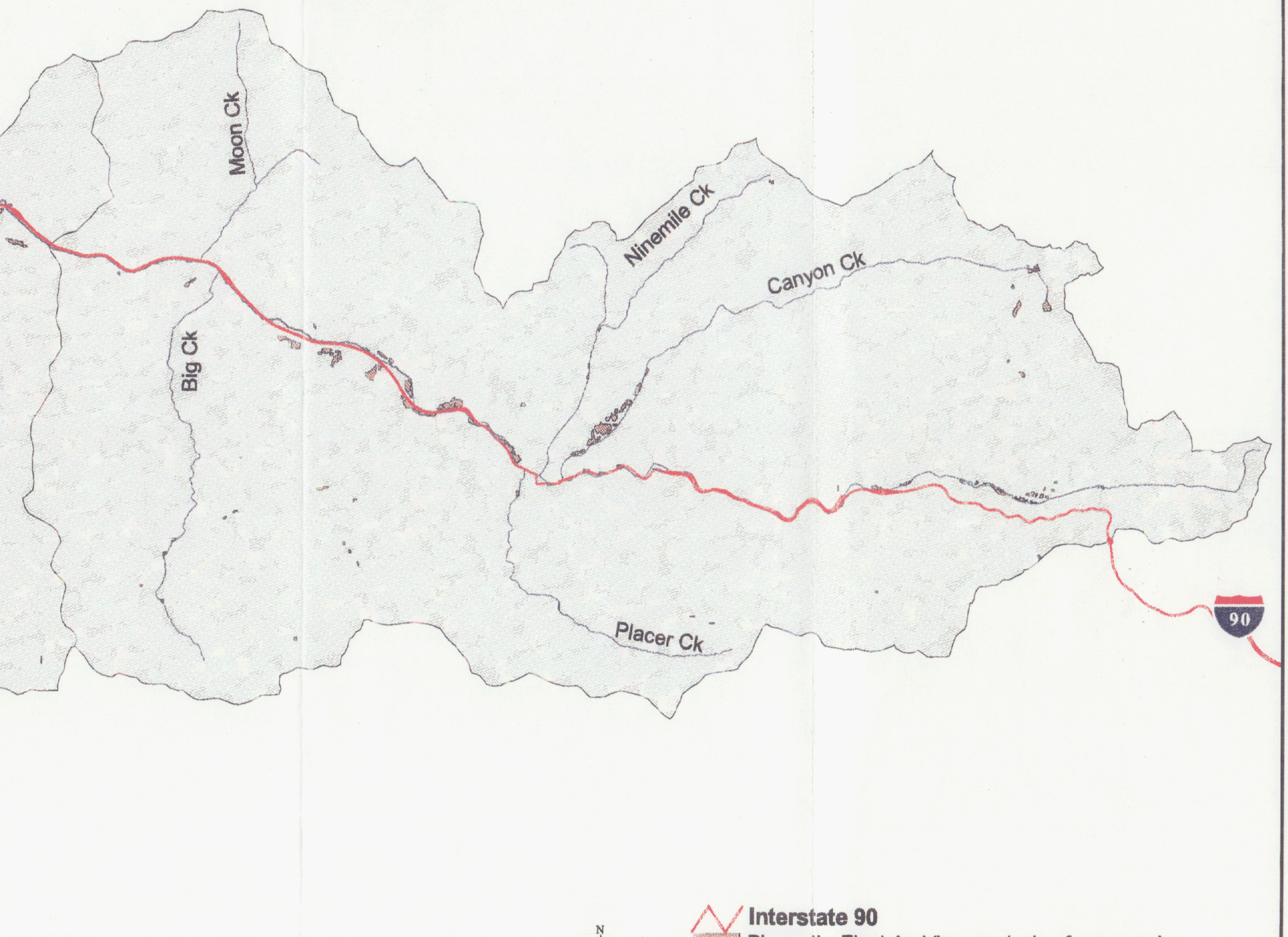
ArcView Analysis
August 1998



North and South Forks of the Coeur d'Alene River). These results were not unexpected given the constraints imposed by the steep, mountainous topography of the upper basin with the few suitable parcels already developed or too close to the floodplains of the South Fork Coeur d'Alene River and it's tributaries.

In contrast the lower Coeur d'Alene Basin provides numerous potential repository locations, primarily in the upland benches where the terrain is rolling and gently sloped with good access. The greatest limitation on potential locations in the lower basin (based on the siting criteria) is that the extensive lateral lakes reach of the lower river and associated wetlands are essentially all floodplain. Also extensive areas of the lower Coeur d'Alene River Basin include metals-contaminated stream banks and sediments that may require remediation or removal.

After the group evaluation of the potential repository locations in the study area (Phase I) and production of a map delineating these locations in the basin (Figure 6), it became apparent that few potentially usable locations were available in the upper basin. The repository-siting group agreed that further modifications of the initial siting criteria would be necessary to identify additional potential sites in the upper basin in order to complete the study. In Phase II the buffer distances around lakes, perennial/intermittent streams, and rivers were reduced (Table 4). Most significant was the decision to evaluate potential sites in the upper basin greater than one acre in size. Also Phase II of the study did not include a collaborative decision making session using the Choice Explorer Software. This allowed a much greater number of potential sites to be evaluated in the upper basin.

Phase II of the study-produced one hundred and sixty-nine acceptable locations for repositories in the upper basin using the modified criteria (Figure 8). These suitable locations in the upper basin reflect limited availability of moderate sloped parcels of land, greater than one acre in size, out of the 100 year floodplain, and within the buffer distance modifications listed in Table 4. The steep, mountainous topography of the upper basin restricts most potential repository areas to locations near the South Fork Coeur d'Alene River and Pine Creek. Both of these areas contain valley reaches with ample width and benches suitable for repositories.

Summary

Use of GIS databases and Arc/Infro software to locate and analyze potential repository sites is an efficient method if software, database and criteria limitations are fully understood beforehand. Results of this pilot project analysis have provided site-specific graphic displays of potential repository sites that should be useful for further field evaluation and ground-truthing.

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APPENDIX 1.

COEUR D'ALENE BASIN REPOSITORY SITING WORKGROUP

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Appendix 2. List of Plants Identified by IDFG CDC* Database

Name	*Buffer Size (meters)*
Bank monkeyflower	100
Beaked sedge	300
Bourgeau's milkvetch	100
Bronze sedge	300
California sedge	100
Case's corydalis	300
Chickweed monkeyflower	100
Clustered lady's-slipper	100
Constance's bittercress	100
Crenulate moonwort	100
Deer-fern	100
Hall's lungwort	300
Henderson's sedge	100
Howell's gumweed	100
Idaho strawberry	100
Large canadian St. John's-wort	300
Leiberg's tauschia	100
Many-fruit false-loosestrife	300
Nail lichen	100
Norther bog clubmoss	300
Pale sedge	300
Phantom orchid	100
Pod grass	300
Red-flowered currant	100
River bulrush	300
Rock stonecrop	100
Sitka mistmaiden	100
Slender woolly-heads	300
String-root sedge	300
Swamp willow-weed	300
Tube lichen	100
Tweedy’s ivesia	100
Water clubrush	300
Western starflower	100
White beakrush	300
White shooting-star	300

**Conservation Data Center*